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## Evaluation of flexor digitorum superficialis function in adolescent baseball players

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**Hypothesis and/or Background:** Increased flexor digitorum superficialis (FDS) tendon activity can be a therapeutic target for elbow disorders in adolescent baseball players. The proportion of adolescent baseball players who can use FDS independently is unknown, and which finger is most often used remains unclear. This study investigated whether adolescent baseball players intentionally used FDS on each finger.

**Methods:** Adolescent baseball players were recruited and assessed for FDS function for each finger using the standard technique.

**Results:** Sixty-nine participants (mean age: 10.4 years) were recruited. Participants numbered 33, 56, 59, and 25 on the throwing side and those numbered 28, 46, 54, and 33 on the nonthrowing side could independently flex the proximal interphalangeal joint while holding their palms in the index, middle, ring, and small fingers, respectively. When assessing both throwing and nonthrowing participants, a significant number of participants could independently flex the proximal interphalangeals of the ring and middle fingers but had difficulty with the index and small fingers ( $P < .001$ ). No significant difference was noted between the throwing and nonthrowing participants in any finger ( $P > .05$ ).

**Discussion and/or Conclusion:** One study reported that participating baseball players with elbow pain have more medial elbow joint space than those without pain symptoms. In another study on finger movements during pitching motion, the force of the thumb, index, middle, and ring fingers was greatest immediately before maximum external rotation. According to both reports, FDS function, especially in the index finger, can be a therapeutic target for medial-sided elbow injuries in adolescent baseball players.

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Approximately 30% of adolescent baseball players experience elbow pain.<sup>15</sup> Although elbow disorders can occur at various sites, medial elbow disorders, which account for more than 50% of cases, are most common in baseball players.<sup>14,16</sup> When medial elbow disorders progress to a severe stage in adults, surgery such as

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medial collateral ligament (MCL) reconstruction is performed in top players, for example, major league baseball players.<sup>5</sup> The frequency of MCL ligament reconstruction in professional baseball players has increased significantly from 2012 to 2018.<sup>12</sup> Furthermore, MCL reconstruction has become more frequent in adolescent athletes.<sup>8,23</sup> Therefore, preventing medial elbow disorders and performing postevent rehabilitation are important for decreasing the number of MCL reconstruction cases in adolescent baseball players.

The valgus stress applied during pitching induces medial elbow disorders.<sup>7</sup> The MCL and flexor/pronator group of the forearm are involved in controlling the elbow joint against valgus stress during pitching.<sup>19,28</sup> The control mechanisms of the MCL and flexor are



**Figure 1** Assessing of flexor digitorum superficialis (FDS) function by flexing proximal interphalangeal (PIP) joint independently.

usually disrupted in patients with medial elbow disorders.<sup>6</sup> Contraction of the flexor digitorum superficialis (FDS) can decrease medial elbow joint space.<sup>9,22</sup> In addition, some studies have reported that increasing the activity of the FDS improves medial elbow disorders.<sup>24</sup> Therefore, increasing FDS activity can be a therapeutic target for elbow disorders in baseball players.

However, the proportion of adolescent baseball players who can use FDS independently is unknown, and which finger is used is unclear. Finger flexion is possible with flexor digitorum profundus activity alone. We hypothesized that most adolescent baseball players would show a lack of independent movement of the proximal interphalangeal (PIP) joint in every finger. The purpose of this study was to investigate whether adolescent baseball players intentionally used FDS on each finger.

## Materials and methods

### Ethical issues

The procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and the Helsinki Declaration of 1975, as revised in 2000. This experimental protocol adhered to the institutional guidelines and was approved by the Institutional Review Board (reference number: 2015-032). Oral informed consent was obtained from all participants, their parents, and the little league to which they belonged.

### Participants

Adolescent baseball players were recruited and assessed for FDS function for each finger using the standard technique. This investigation was performed with the cooperation of local Little League Federation. The inclusion criterion was a player who had registered in this federation. The exclusion criterion was a player and/or parents who were not allowed to participate in our investigation.

### Assessment of FDS function

Our investigation assessed the FDS function according to Daniels' manual strength and the standard technique previously reported.<sup>2,30</sup> The test was performed in the sitting position. Participants placed their hands on a desk with elbow flexion and forearm supination. The participants flexed their fingers individually, whereas an observer held the hand (Fig. 1). Each participant watched a test video on a tablet in advance, and after confirming the test method, the index, middle, ring, and small fingers were

evaluated on both sides. When the participant could independently flex the PIP joint in each finger, we considered this as a positive result for FDS function. Each participant watched a test video on a tablet in advance, and after confirming the test method, the index, middle, ring, and small fingers were evaluated on both sides.

### Statistical analysis

Statistical analyses were performed using commercial software (SPSS, version 28.0; IBM, Armonk, NY, USA). The chi-square test was used to compare the rate of positive FDS function among the 4 fingers. Effect size (ES) was assessed using Cramer's V. We also assessed the prevalence of positive FDS function between the throwing and nonthrowing hands. For all statistical analyses, significance was defined as  $P < .05$ . On the strength of Cramer's V,  $ES < 0.3$  was defined as weak,  $0.3 \leq ES < 0.5$  was defined as moderate, and  $ES \geq 0.5$  was defined as strong.<sup>4</sup>

## Results

### Profile of participants

The participants were 69 adolescent baseball players who participated in a baseball elbow examination. The average age of the participants was 10.4 years, and the sex ratio was 63 boys and 6 girls. The participants had an average height of 141.5 cm, an average weight of 35.8 kg, and an average body mass index of 17.8 kg/m<sup>2</sup>. The average palm size was 15.3 cm for both the throwing and nonthrowing sides. Four of the players had a history of medial elbow pain.

The differences between each finger on the throwing and nonthrowing sides are shown in Table 1. On the throwing side, participants who were numbered 33, 56, 59, and 25 could independently flex the PIP while holding their palms in the index, middle, ring, and small fingers, respectively. On the nonthrowing side, participants who were numbered 28, 46, 54, and 33 could independently flex the PIP while holding their palms in the index, middle, ring, and small fingers, respectively. On both sides, most participants could independently flex the PIP of the ring and middle fingers but had difficulty with the index and small fingers ( $P < .001$ ). Cramer's V values of the throwing and nonthrowing sides were 0.436 and 0.303, respectively.

No significant differences were noted between the throwing and nonthrowing sides in any of the fingers with independent flexion of the PIP ( $P = .25, .39, 0.27, \text{ and } 0.09$  for the index, middle, ring, and small fingers, respectively; Table 1).

**Table 1**

Number and percentage of adolescent participants who could perform proximal interphalangeal (PIP) joint flexion independently in each finger.

Side	Finger				P value
	Index	Middle	Ring	Small	
Throwing, n (%)	33 (47.8)	56 (81.1)	59 (85.5)	25 (36.2)	<.001
Nonthrowing, n (%)	28 (40.5)	46 (66.6)	54 (78.2)	33 (47.8)	<.001
P value	.25	.39	.27	.09	

n, number of participants who could perform PIP joint flexion independently.

## Discussion

This study investigated a representative percentage of the population who can perform independent FDS function in each digit in adolescent baseball players. The results of this study showed that the ring finger had the highest FDS function for both the throwing and nonthrowing sides. Next, the middle finger functioned well, whereas the index and small fingers had difficulty using FDS. In a quantitative evaluation of FDS function in adults, the ring and middle fingers were the largest and capable of PIP flexion, and the small finger showed the highest percentage of lack of FDS function.<sup>20,21,27,30</sup> In our investigation of adolescent baseball players, the independent FDS function of the middle and ring fingers was significantly higher than that of the small finger, a similar finding to those in previous studies. Thus, concomitant with previous reports and our findings, FDS function in each finger is not related to aging. Cadaveric studies have revealed variations ranging from anomalous muscle bellies to connections between musculotendinous units to complete absence of the small finger FDS, with the latter having a reported incidence ranging from 0% to 20%.<sup>10,26</sup> Therefore, FDS of the small finger can be a lower function of FDS, compared with that of other fingers.

Adolescent and college-aged baseball players with elbow pain have more medial elbow joint space than players without pain symptoms.<sup>25,29</sup> Recently, studies have reported that increasing FDS function increases the medial-side stability in valgus stress and helps to improve baseball players with ulnar collateral ligament injury.<sup>9,18,22,24</sup> Regarding finger movements during pitching motion, the force of the thumb and ring fingers is greatest just before the maximum shoulder external rotation, whereas the force produced from the index and middle fingers reaches the peak just before the maximum shoulder external rotation and ball release.<sup>11</sup> Previous studies using cadavers have reported that the index, small, and independent small fingers adhere to the anterior oblique ligament of the MCL.<sup>1</sup> In addition, it has been reported that the ring and middle fingers may originate from the anterior oblique ligament.<sup>17</sup> Regarding the anatomical features of the FDS, the automatic flexion angle of the PIP joint is related to the tension of the FDS. This is a factor in the difference in the FDS function among fingers.<sup>30</sup> FDS tension was greatest in the middle and ring fingers, followed by the index finger and small finger.<sup>3,13</sup> In addition, the individual FDS muscle contraction, particularly in the index and middle fingers, decreased the medial elbow joint space under valgus load conditions.<sup>9</sup> The sonographic elbow medial joint space under valgus stress with FDS contraction was the most significant predictive factor for the successful treatment of ulnar collateral ligament elbow injury.<sup>24</sup> In this study, the rate of adolescent baseball players who could use the index FDS independently was only 48% on the throwing side, although the rates for the middle and ring finger FDS were 81% and 86%, respectively. According to previous reports, FDS function can be a therapeutic target for medial-side elbow injuries in adolescent baseball players, especially for the index finger. Further investigations are needed to

confirm the relationship between FDS function and medial elbow pain.

## Limitations

First, this was a cross-sectional study and could not confirm the direction of the association. In this study, we did not mention whether the participants had medial elbow pain or not. Further investigations are needed to confirm the relationship between FDS function and medial elbow pain.

## Conclusions

The FDS function was evaluated in adolescent baseball players. The FDS function of the middle and ring fingers was high for both of the pitching and nonthrowing sides. However, fewer than half of the players could not use the FDS of the index and small fingers independently.

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